A New Variety of *Musa itinerans* (Musaceae) in Taiwan

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ABSTRACT. *Musa itinerans* Cheesman var. *formosana* (Warb.) Häkkinen & C. L. Yeh is one of the three wild bananas in Taiwan and represents the taxon previously recognized as *M. formosana* (Warb. ex Schum.) Hayata [≡ *M. basjoo* Siebold & Zucc. ex Iinuma var. *formosana* (Warb. ex Schum.) S. S. Ying]. The gross morphology of *M. itinerans* var. *formosana* is stable. Some populations without variegation on the pericarps and the bracts of male buds were mainly found in a restricted area of northeast Taiwan. The morphological characteristics of the nonvariegated populations are otherwise similar to those of *M. itinerans* var. *formosana*. Their principal distinction is based on the absence of the purplish red streaking on both the pericarps and the male, fertile bracts. This character of nonvariegation is stable across the taxon's habitat and as cultivated through a 9-year period of observation. From molecular evidence, the DNA sequence for the ITS region of ribosomal DNA (rDNA) is highly similar in both populations. The nonvariegated population is herein segregated as the new variety, *M. itinerans* var. *kavalanensis* H. L. Chiu, C. T. Shii & T. Y. A. Yang. Photos for the three varietal taxa, *M. itinerans* var. *chinensis*, variety *formosana*, and variety *kavalanensis*, and a key to Taiwanese wild bananas are also provided.

Key words: ICUN Red List, *Musa*, Musaceae, native banana, Taiwan.

The Musaceae are distributed throughout tropical Asia, the Pacific Islands, Africa, and Australia. As currently circumscribed, the family includes three genera, *Musa* L., *Ensete* Horan., and *Musella* (Franch.) C. Y. Wu (Cheesman, 1947; Li, 1978). The largest and most economically important genus in this family is *Musa*, which contains roughly 60 to 70 species (Häkkinen & Väre, 2008), all native to Southeast Asia, ranging from India, Thailand, China, Taiwan, and south to New Guinea and Queensland in Australia. *Musa acuminata* Colla and its hybrids with *M. balbisiana* Colla account for edible bananas and plantains grown worldwide (Simmonds, 1962; Gawel et al., 1992).

Three native *Musa* species in Taiwan have been recognized in the literature, including *M. itinerans* Cheesman var. *formosana* (Hayata) Häkkinen & C. L. Yeh (also known as *M.* ×*paradisiaca* var. *formosana* Warb. ex Schum., *M. formosana* (Warb. ex Schum.) Hayata, or *M. basjoo* Siebold & Zucc. ex Iinuma var. *formosana* (Warb. ex Schum.) S. S. Ying), *M. insularimontana* Hayata, and *M. yamiensis* C. L. Yeh & J. H. Chen, respectively. The first taxon, *M. itinerans* var. *formosana*, has been studied by several taxonomists, e.g., Kao and Lai (1978), Ying (1985), Liaw (1992), Ying (2000), Chiu et al. (2004, 2007, 2010), Chiu (2005), Häkkinen and Väre (2008), and Häkkinen et al. (2010). This taxon was published in 1900 by Schuman, and in 1917 Hayata later transferred it from a variety to a distinct species, i.e., *M. formosana*; however, this rank was also accepted by Kao and Lai (1978), Wu and Kress (2000), Yang et al. (2001), Chiu et al. (2004, 2007, 2010), and Chiu (2005). Furthermore, Ying transferred this Taiwanese native species as a variety of a different species, i.e., *M. basjoo* var. *formosana* in 1985.

Musa basjoo has been commonly referred to as the Japanese fiber banana and is native to the Ryukyu Islands (Baker, 1891; Cheesman, 1948; Wu & Kress, 2000; Turner et al., 2002). In fact, *M. basjoo* is also native to China and grows very commonly in the southern and southwestern parts of the country

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(Amano et al., 1992; Wu & Kress, 2000; Liu et al., 2002). However, the banana cultivated in Ryukyu for fiber actually differs from those plants in China and was recognized as *M. balbisiana* (Jarret, 1987; Amano et al., 1992). *Musa itinerans* var. *formosana* can be easily distinguished from *M. basjoo* by its bract imbrication subtending the male bud (vs. the bracts imbricate at the tip in *M. basjoo*).

Based on the diagnostic character of rhizomatous suckering, *Musa itinerans* var. *formosana* is morphologically close to *M. itinerans* Cheesman, which is also native to China (Liu, 2001). The relationship to *M. itinerans* is supported by phylogenetic analyses of the banana family based on evidence from the ITS region of ribosomal DNA (rDNA) and chloroplast (*trnL-F*) DNA (Liu et al., 2010). Therefore, the combination for *M. formosana* was proposed as *M. itinerans* var. *formosana* by Häkkinen et al. in 2010.

The complex *Musa itinerans* is a highly polymorphic species and several varieties have been reported (Häkkinen et al., 2008, 2010). However, the general morphology of *M. itinerans* var. *formosana* is quite stable and the principal diagnostic characters are as follows: the inflorescences are in compact bunches with purplish red pericarps, the male buds are ovate-lanceolate and variegated with purplish red pigmentation, and the young leaves are usually reddish green abaxially (Chiu et al., 2004; Chiu, 2005). During our field collections over the past 10 years, several populations that lack variegated pericarps and have yellowish green bracts subtending the male buds were found in northeastern Taiwan. For other characteristics, these populations were similar to those of *M. itinerans* var. *formosana*, yet with the principal difference being the lack of variegation, with the pale green pericarps and yellowish green bracts of male buds. These two characters have been stable in each population observed in the field as well as throughout their conserved repository at Taiwan Agricultural Research Institute (TARI) during a 9-year period of observation. Based on detailed morphological comparison involving the relevant literature, and the close similarity of the DNA sequence for the ITS region of rDNA between populations (Chiu, 2005), we treat these nonvariegated populations with pale green pericarps and yellowish green bracts that subtend the male buds as the new variety *M. itinerans* var. *kavalanensis* H. L. Chiu, C. T. Shii & T. Y. A. Yang. The taxonomic description for this newly described taxon, comparable photographs for all three varietal taxa in *M. itinerans*, and a key to Taiwanese bananas are provided.

Materials and Methods

Based on the large, fleshy character of *Musa* plants and the ephemeral aspects of the flowers, their associated herbarium specimens represent poor material to examine (Argent, 2000). Fresh material as clones of the nonvariegated populations of *M. itinerans* were collected from northeastern Taiwan and conserved at TARI, Taichung, Taiwan. These characteristics were recorded according to the Revised List for Banana Descriptors (IBPGR, 1984; IPGRI-INIBAP/CIRAD, 1996). Our knowledge of the nonvariegated populations is based on the study of more than 50 living accessions in their native habitat and at the conserved repository at TARI.

Taxonomic Treatment

1. Musa itinerans Cheesman, Kew Bull. 4(1): 23. 1949. TYPE: Myanmar [Burma]: Myitkyina Distr., Tagwin Chaung, evergreen forests, 400 ft., 24 Nov. 1928, *C. E. Parkinson 1761* (lectotype, designated by Liu et al. [2002: 79], K not seen).

1a. Musa itinerans var. **chinensis** Häkkinen, Novon 18(1): 51. 2008. TYPE: China. Guangdong: Conghua, Daling Mtn., 500 m, 2 Apr. 2006, *M. Häkkinen 514* (holotype, IBSC not seen; isotypes, H not seen, HITBC not seen, MO not seen). Figure 1A, B.

Selected specimen examined. TAIWAN. **Hsinchu Co.:** Peipu Township, 20 May 2008, *H. L. Chiu 2* (TNM).

1b. Musa itinerans var. **formosana** (Warb. ex Schum.) Häkkinen & C. L. Yeh, Acta Phytotax. Geobot. 61(2): 44. 2010. Basionym: *Musa* ×*paradisiaca* var. *formosana* Warb. ex Schum., Pflanzenr. (Engler) IV (Heft 1): 21. 1900. *Musa formosana* (Warb. ex Schum.) Hayata, Icon. Pl. Formosan. 6 (Suppl.): 83. 1917. *Musa basjoo* Siebold & Zucc. ex Iinuma var. *formosana* (Warb. ex Schum.) S. S. Ying, Mem. Coll. Agric. Nation. Taiwan Univ. 25: 100. 1985. TYPE: Taiwan [Formosa]. Uchiko, Yusuikyo, 17 Sep. 1916, *B. Hayata s.n.* (neotype, Häkkinen & Väre [2008: 88], TI). Figure 1C, D.

Selected specimens examined. TAIWAN. **Hsinchu Co.:** Wufong Township, 25 June 2010, *H. L. Chiu & K. C. Chang 10* (TNM). **Ilan [Yilan] Co.:** Tatung Township, Tuchang, 24 June 2010, *H. L. Chiu 8*, *H. L. Chiu 9* (TNM), 24 June 2010; Songlou, Prov. #7 Hwy. 98.2 Km, 24 June 2010, *H. L. Chiu 7* (TNM); Wangliuan, 15 June 2010, *H. L. Chiu & Y. C. Chen 3* (TNM). **Nantou Co.:** Luku Township,

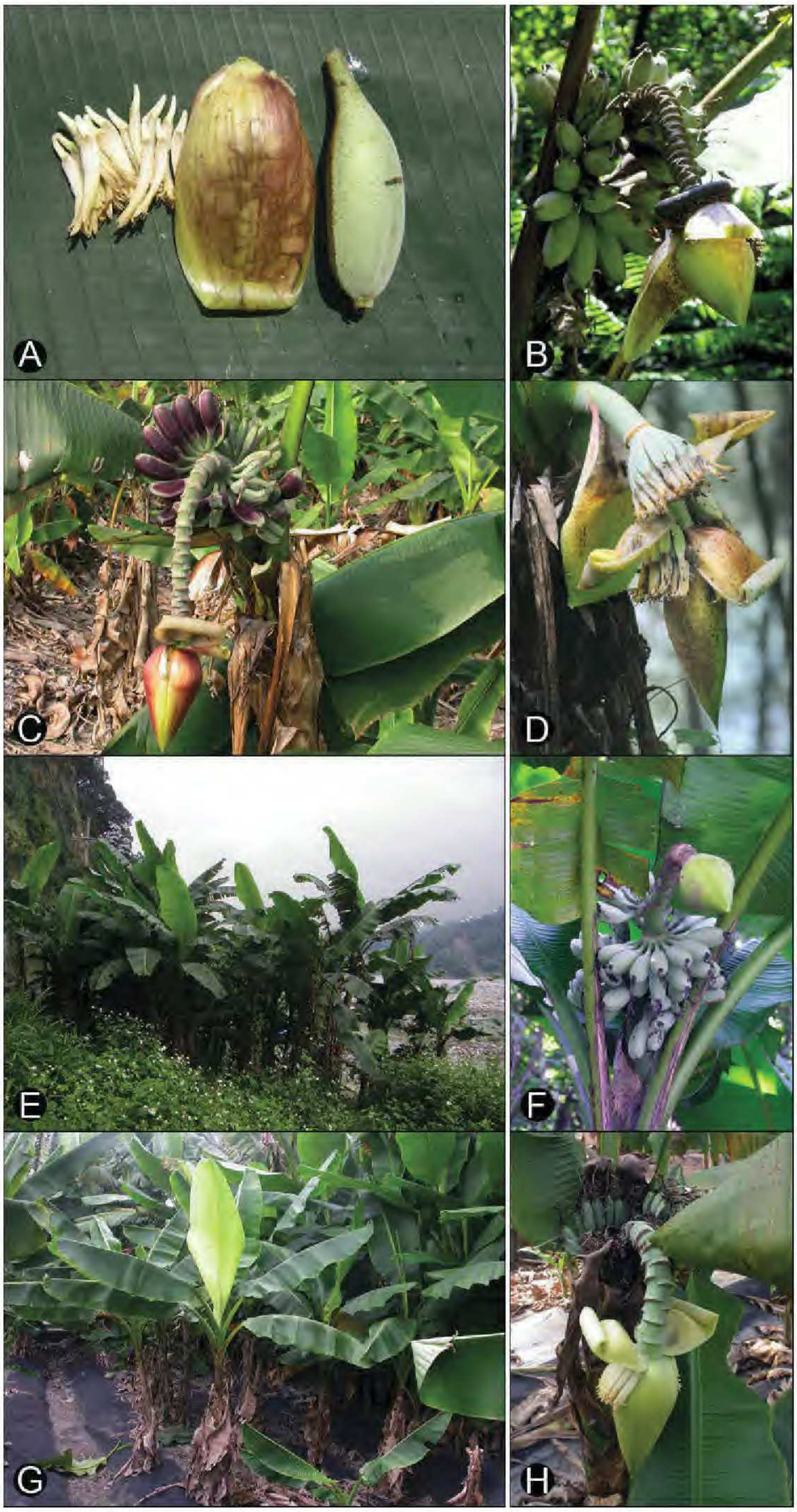

Figure 1. A–B. *Musa itinerans* var. *chinensis* Häkkinen. —A. Male bud yellowish green with purple-red streaks and one fruit finger with pale-green pericarp and fertile male flowers. —B. Inflorescence with pale-green pericarps and yellowish green bracts with purple-red streaks. C–D. *M. itinerans* var. *formosana* Häkkinen & C. L. Yeh. —C. Inflorescence with yellowish green bracts variegated with purple-red streaks and pink-red pericarps if ovaries were fertilized or pale green pericarps if ovaries were not fertilized. —D. The basal nodes of the inflorescence, bearing female flowers with yellow-green bracts streaked with purple-red. E–H. *M. itinerans* var. *kavalanensis* H. L. Chiu, C. T. Shii & T. Y. A. Yang. —E. Plants in the field, from Nioudou, Yilan Co., the type locality. —F. Inflorescence in field. —G. Plants under cultivation at TARI. —H. Developing inflorescence at TARI. All photos were taken by H. L. Chiu.

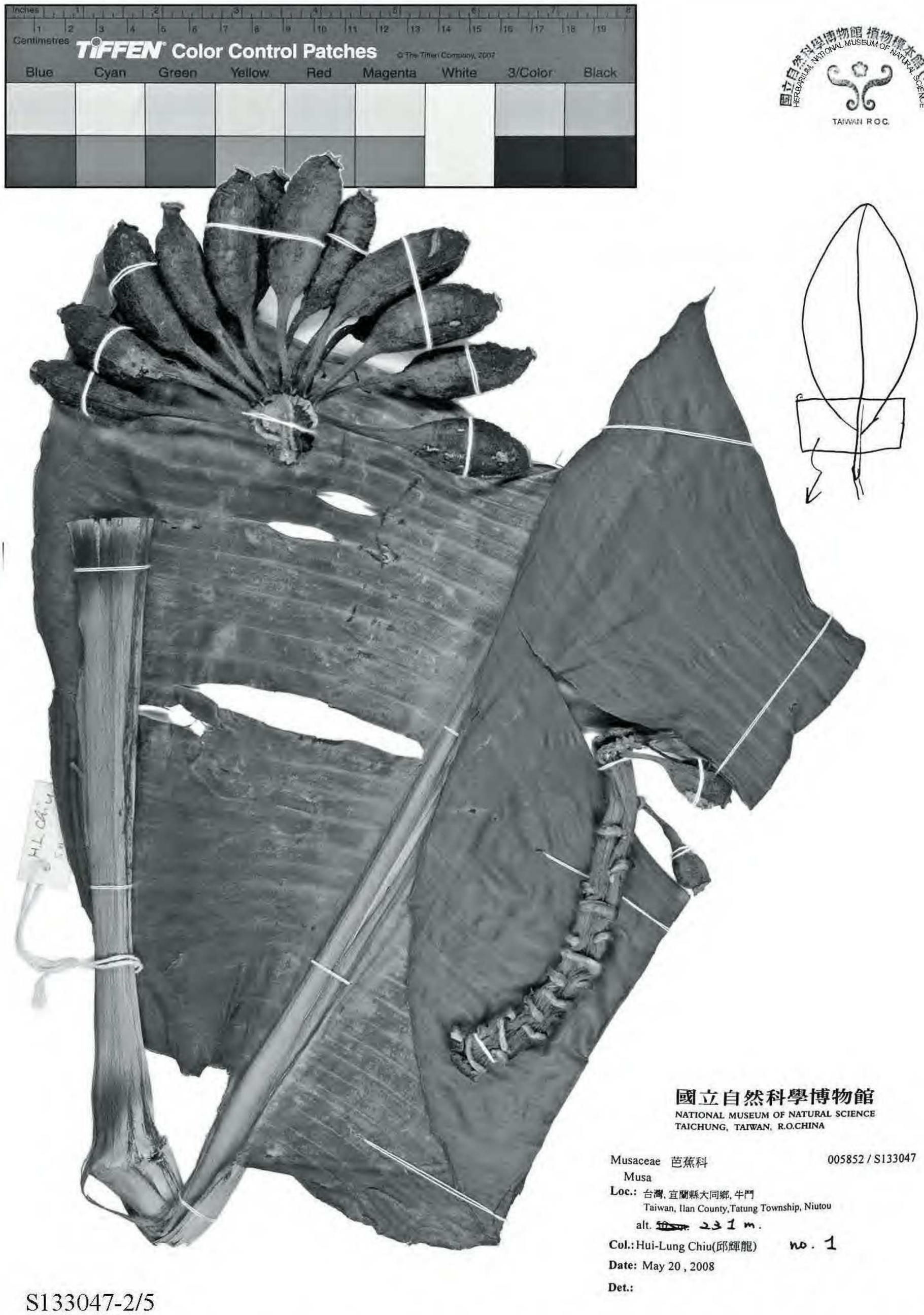

Figure 2. Holotype of *Musa itinerans* var. *kavalanensis* H. L. Chiu, C. T. Shii & T. Y. A. Yang (*Chiu 1*, sheet 2 of 5, TNM).

Shanlinhsi, Chinese Zodiacal Sign Ox-Tiger, 9 Dec. 2008, *T. Y. A. Yang et al. 21187* (TNM). **Taitung Co.:** Taimali Township, Taimali logging track, 29 Sep. 1999, *S. T. Chiu 5482* (TNM). **Taoyuan Co.:** Fuhsing Township, Neikueihui, 16 Oct. 2008, *C. M. Wang 12331* (TNM).

Notes. Musa itinerans var. *formosana* is distributed across the entire island of Taiwan as well as its offshore islands in subtropical and tropical areas at altitudes from 200 to 1200 m, along roadsides, in river valleys and ravines, and on gentle or steep slopes. Large populations often occur in valleys or along rivers. It can withstand frost or snow when this occurs. Where frost kills the leaves, the pseudostem remains alive and new leaves emerge as temperatures rise. However, *M. itinerans* var. *chinensis* occurs only occasionally among the populations of variety

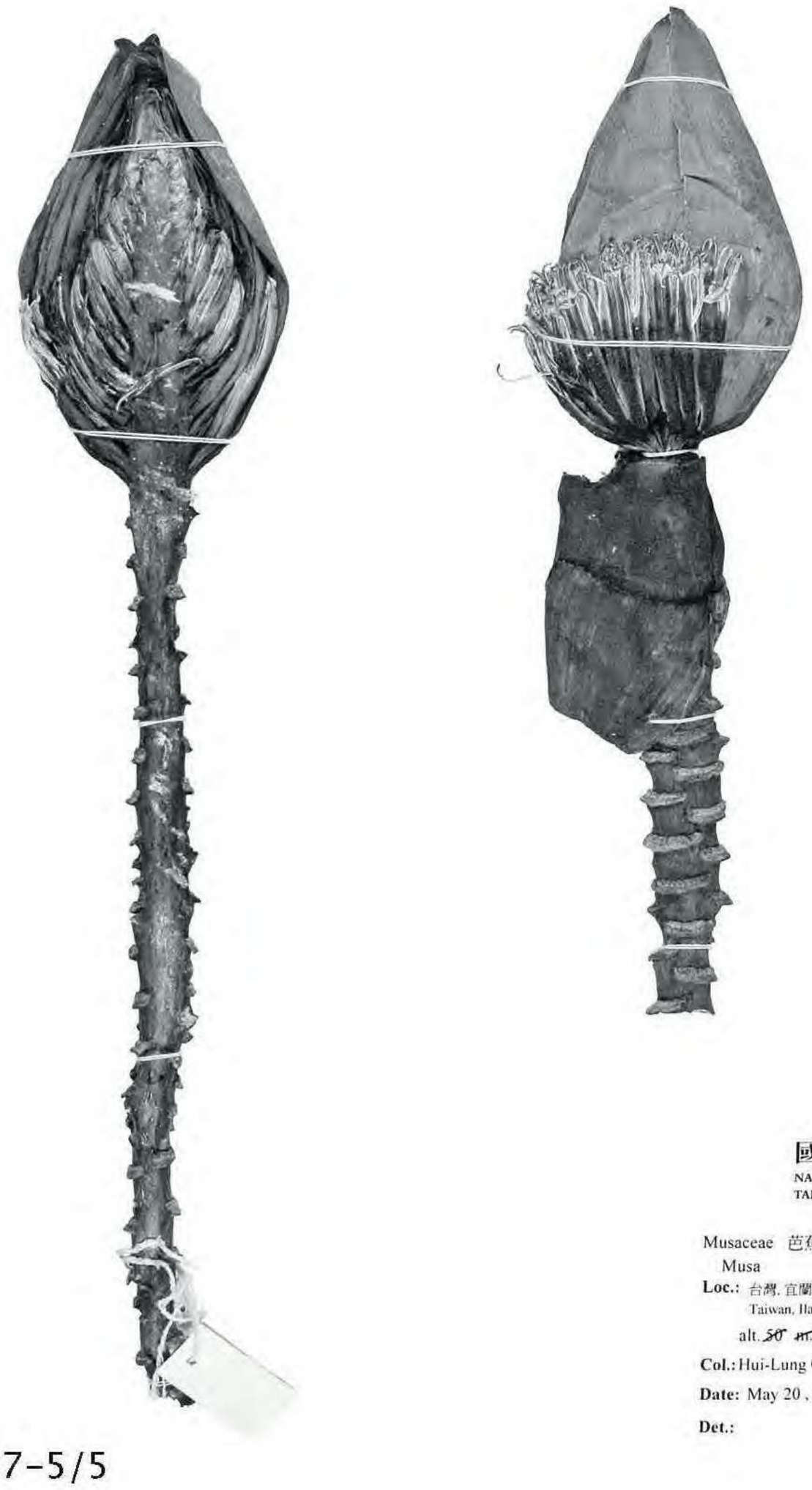

Figure 3. Isotype of *Musa itinerans* var. *kavalanensis* H. L. Chiu, C. T. Shii & T. Y. A. Yang (*Chiu 1*, sheet 5 of 5, TNM).

formosana, and its chromosome number of $2n = 22$ was determined by Chiu et al. (2010).

The pigmentation of *Musa itinerans* var. *formosana* on young leaves, pericarps, and bracts of male buds is developmentally uniform, but varies in the intensity and area of coverage in variegated streaking. The extent of streaking on the pericarps and bracts of the male buds can range from minimal to entirely covering the surface, and the pigmented intensity on the pericarps may be light initially and then darken with maturity. The principal difference between variety *formosana* and variety *chinensis* is the purplish red streaking on the pericarps only. In contrast, the pericarps of variety *chinensis* remain pale green even

at maturity. This variegation or its absence was a stable character throughout the field investigations. Otherwise, it is hard to distinguish variety *chinensis* from variety *formosana* at vegetative stages.

1c. Musa itinerans var. **kavalanensis** H. L. Chiu, C. T. Shii & T. Y. A. Yang, var. nov. TYPE: Taiwan. Ilan [Yilan] Co., Tatung Township, Nioudou, 20 May 2008, *H. L. Chiu 1* (holotype, TNM S133047, 1 of 5; isotypes, TNM S133047, 2 to 5 of 5 [4]). Figures 1E–H, 2, 3.

Haec varietas a *Musa itinerante* Cheesman var. *formosana* (Warb. ex Schum.) Häkkinen & C. L. Yeh pericarpio atque bracteis fertilibus omnibus non rubro-variegatis differt.

Plants freely stoloniferous, developing long rhizomes 15 cm or more from the parent plant, position vertical, up to 5 suckers; mature pseudostems 2.5 m tall or more, to 4 m, 28–44 cm diam. at base, green with varying development of red-brown pigmentation according to age and exposure; the pseudostem covered with varying amounts of dead brown leaf sheaths, the underlying color light green with large red-brown blotches, shiny; sap watery. Leaf sheaths and petioles devoid of wax; leaf blades developing on the fourth, fully unfolded leaf basipetally from the plant apex, ca. 175–220 × 47–59 cm, bases obtusely rounded to oblique, entire, the apex obtuse, lateral venation pinnate and parallel, midrib usually prominent, blades often tearing between the lateral veins, yellowish green to green on both surfaces, glabrous; petioles 30–40 cm, usually green, caniculate with the canal wide, margins narrow, membranous and erect, not clasping the pseudostem. Inflorescence at first semi-erect to horizontal and then falling vertically downward; peduncle ca. 55–80 cm, robust, pale green to rusty brown, densely puberulent; sterile bracts 2, bracts deciduous at opening of the first flowers; basal flowers bisexual, the others male; spathe long-lingulate, 31.7 × 11.4 cm wide at center, apex convolute, bracts yellowish green, revolute and lifting one at a time after flowering, with the subsequent 1 to 2 bracts acropetally revolute, lifting before the older bract is deciduous; bract scars prominent. Flowers 11 to 13 per bract, biseriate, ovary inferior, pale green, glabrous, ca. 4.6 cm, markedly 5-angled, locules 3, ovules disposed in 4 rows; compound tepals ca. 4.8 cm, with 2 prominent thickened keels, ribbed at the dorsal angles, with 5-lobed, pale yellow apex, free tepals translucent white, ca. 3.2 cm, oblong-acuminate, smooth; stamens 5 with sterile pollen, ca. 5.2 cm, filaments white, anther pale yellow; style straight, ca. 4.1 cm, creamy white, stigma capitate, grayish black after pollination. Male buds lanceolate, 15.8 × 7.5 cm, pendulous, bracts yellowish green on both sides, convolute at the tip; bract lifting sequentially as 1 bract at a time, lifting and revolute, similar to those subtending the lower flowers; bract scars prominent. Male flowers 14 to 15 per bract, in 2 rows, falling with the bract, compound tepals usually 5-lobed, ca. 4.5 cm, pale yellow, central lobes smaller than the outer lobes; free tepals translucent white, ca. 2.2 cm, oblong-acuminate, stamens 5, filaments white, ca. 4.3 cm; fertile gynoecium 1, style straight, stigma cream, ca. 4.3 cm, ovary arched, pale green, glabrous, 1.1 cm. Fruits bunch nearly horizontally, compact, with 3 to 10 hands per bunch. Individual fruit usually negatively geotropic, ca. 6.7–8.5 × 2.5–2.8 cm in diam., ca. 21–38 g in weight, straight, slightly ridged, obscurely 5-angled at maturity, apically blunt with persistent floral remains; fruit pedicels 1.1–1.4 cm, pale green, minutely puberulent; immature pericarp whitish green, minutely puberulent, becoming pale green and splitting lengthwise occasionally at maturity, dull yellow at full ripeness, not strongly aromatic, sweet and sour taste; seeds small, dark brown, warty, ca. 2.1 × 4.1–4.8 mm diam., irregularly angulate-depressed, 100 seeds with a weight of 2.9 g.

Etymology. The epithet of the new variety honors the traditional name of the aboriginal people in Yilan County (the Kavalan).

Distribution and habitat. The known populations of *Musa itinerans* var. *kavalanensis* occur in mountainous areas at elevations from 220 to 820 m, along the 202 logging track (Yingshih village) on gentle slopes and the roadside of Prov. 7 Highway (Nioudou village), Yilan County, which is located in northeastern Taiwan. No individual or population of variety *kavalanesis* has been found within the distributional areas of either *M. itinerans* var. *formosana* or variety *chinensis*.

IUCN Red List category. Musa itinerans var. *kavalanesis* was investigated by the authors in Taiwan from 1999 to 2010. For its conservation assessment, IUCN Red List categories were applied (IUCN, 2001). These native banana populations occur mainly in open places in mountainous areas at Nioudou and Yingshih villages, Yilan County, at altitudes from 220 to 820 m. Both observed and conserved materials of *M. itinerans* var. *kavalanesis* and variety *formosana* were occasionally seen as growing sympatrically. However, no obvious hybrids were observed in those populations. This taxon is of minimal conservation concern and should be considered Least Concern (LC).

Table 1. Diagnostic morphological characters of the three varieties of *Musa itinerans* Cheesman in Taiwan and Hainan. *Musa itinerans* var. *formosana* (Warb. ex Schum.) Häkkinen & C. L. Yeh and *M. itinerans* var. *kavalanensis* H. L. Chiu, C. T. Shii & T. Y. A. Yang are found in Taiwan; *M. itinerans* var. *hainanensis* Häkkinen & X. J. Ge occurs in Hainan. The description of variety *formosana* is based on personal observations by the authors, and the description of variety *hainanensis* is taken from Häkkinen et al. (2010).

	var. *formosana*	var. *hainanensis*	var. *kavalanesis*
Plant height	to 3 m	to 4 m	to 4 m
Rhizome length	0.3–1 m from parent plant	0.5–2 m from parent plant	0.3–1 m from parent plant
Number of suckers	to 5 (rhizomatous)	to 5 (rhizomatous)	to 5 (rhizomatous)
Leaf habit	normal (intermediate)	normal (erect)	normal (intermediate)
Underlying color of the pseudostem	light-green	light-green	light-green
Pigmentation of the underlying pseudostem	red-brown to black blotches	large black blotches	red-brown blotches
Sap consistency	watery	milky	watery
Petiole margins	erect	spreading	erect
Leaf size	180 × 52 cm	250 × 50 cm	175–220 × 47–59 cm
Color of adaxial surface of leaf	green	dark green	green
Peduncle color	pale green to rusty brown	green to rusty brown	pale green to rusty brown
Basal flowers	8 to 12 in two rows on average, bisexual	15 in two rows on average, bisexual with androecium reduced	11 to 13 in two rows on average, bisexual
Male bud shape and size	ovate-lanceolate, 13 × 7 cm	ovoid, 12 × 7 cm	lanceolate, 15.8 × 7.5 cm
Color of the external face of the bract	yellowish green with purple-red streaking apically	pale yellow, tinted with green	yellowish green
Male bract lifting and dehiscence pattern	lifting one bract at a time, revolute	lifting two bracts at a time, revolute	lifting one bract at a time, revolute
Male flowers per bract	12 to 17 in two rows	17 in two rows on average	11 to 13 in two rows
Number of fruits	3 to 11 hands, 8 to 12 fruits per hand on average	9 hands, 15 fruits per hand in two rows on average	3 to 10 hands, 11 to 13 fruits per hand on average
Fruit length and shape	7 cm, straight and ridged	6.5 cm, rounded	6.7–8.5 cm, straight and slightly ridged
Fruit pedicel	3 cm, pubescent	4.5 cm, pubescent	1.1–1.4 cm, minutely puberulent
Immature pericarp color	pale green tinted with purple-red spots	pale green	whitish green
Mature pericarp color	pale green tinted with variable purple-red streaks	dull black	pale green
Fruit at maturity	splitting lengthwise occasionally	splitting lengthwise	splitting lengthwise occasionally

Note. A new variety of *Musa itinerans* was described recently as variety *hainanesis* Häkkinen & X. J. Ge by Häkkinen et al. (2010), with pale green pericarps equipped with yellowish green bracts of male buds. The distinguishing characteristics of *M. itinerans* var. *kavalanesis*, variety *hainanesis*, and variety *formosana* are provided in Table 1.

Paratypes. TAIWAN. **Ilan [Yilan] Co.:** Tatung Township, Yingshih, #202 logging track 4.2 km, male flowers, 2 Sep. 2010, *H. L. Chiu 12* (K, MO, TAI, TI, TNM), #202 logging track 5.8 km, female flowers, 2 Sep. 2010, *H. L. Chiu 14* (KUN, TNM).

KEY TO THE SPECIES OF *MUSA* AND VARIATIONS OF *M. ITINERANS* IN TAIWAN

1a. Plants rhizomatous.
  2a. Fertile bracts yellowish green; pericarps pale green, both lacking reddish variegation..... *Musa itinerans* var. *kavalanensis*
  2b. Fertile bracts yellowish green, variegated with purplish red streaks toward apex.
    3a. Pericarps pale green..... ..... *Musa itinerans* var. *chinensis*
    3b. Pericarps pale green, variegated with purplish red streaks..... ..... *Musa itinerans* var. *formosana*

1b. Plants not rhizomatous.
4a. Bracts dark purplish red abaxially.....
..... *Musa insularimontana* Hayata
4b. Bracts yellowish green abaxially.....
..... *Musa yamienesis* C. L. Yeh & J. H. Chen

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